

Review Article

Summary of research on fine management of engineering project construction under the concept of intelligent construction

ABSTRACT

For many years, the traditional extensive and low information management mode has been adopted in the construction of engineering projects in China. The construction of the construction site has the characteristics of labor intensive, the input of a large number of labor, it is difficult to achieve effective control of each operator; In the quality control process of construction process activities, the input of materials is wide and large, and it is difficult to achieve comprehensive control of material factors, such as the quality of sand, stone, brick, etc., is relatively discrete, coupled with materials often enter the market at any time, how to achieve real-time, comprehensive and effective control of materials is also a difficult topic. In addition, the development of the construction industry in our country is depressed at the present stage, so the traditional management mode needs to change. This paper puts forward the research direction of fine management of engineering project construction under the concept of intelligent construction. Under the background of intelligent construction, the paper summarizes the ways to achieve the fine management of engineering projects, so as to be applied to engineering practice.

Keywords: Construction industry; building intelligently; construction; fine management

1. INTRODUCTION

Since the 18th National Congress, the construction industry has developed steadily, and the status of the pillar industry of the construction industry has gradually stabilized. However, in recent years, the upward trend of the GDP of China's construction industry has gradually slowed down, and the profits of the general contracting and professional contracting construction enterprises with qualification grades have declined for two consecutive years [6-10]. The traditional extensive management mode leads to a large waste of resources in the construction process, the delay of construction period due to the delay of material scheduling, and the endless design changes due to the delay of information transmission. The traditional management mode needs to be changed to the direction of refinement. In some regions or enterprises, the lack of advanced information technology and tools leads to the limitation of project progress management level and efficiency [11-14]. In order to overcome this challenge, it is necessary to strengthen technical training and promotion, improve the technical ability of the project team, introduce advanced information tools and technologies, and realize the digitalization and intelligence of the project schedule management. ^[1]At the same time, the smart construction concept proposed by Dr. Yang Baoming, the founder of

Luban Software, assembles the digital nervous system into the construction management to achieve the fine management of the construction of engineering projects, which can save resources and energy, reduce pollution, and make the operating environment fair and transparent, and enterprise management more efficient and fine.

2. OUR COUNTRY BLDG DEVELOPMENT PRESENT SITUATION

Since the 18th CPC National Congress, the added value of China's construction industry has always accounted for about 7% of GDP, and is a pillar industry of the national economy, which plays an important role in promoting economic and social development and ensuring people's happiness. According to the release of the National Bureau of Statistics, as shown in Figure 1 and 2, the total output value of the construction industry has increased year by year since entering the 21st century, and exceeded 30 trillion in 2022, and the growth rate has gradually slowed down since 2021. The profits of the national qualified grade general contracting and professional contracting construction enterprises increased at an average annual growth rate of 19.26% from 2010 to 2014, and the growth rate gradually slowed down from 2015 to 2021, and the profits of the national qualified grade general contracting and professional contracting construction enterprises declined for two consecutive years from 2020 to 2021 [15-20]. While the total output value is slowing down, the profits of construction enterprises have declined for two consecutive years, indicating that the construction industry is in a bottleneck period of development. How to make construction enterprises obtain more considerable profits while completing construction with high quality and stabilize the position of the construction industry as a pillar industry is the main purpose of the current research.

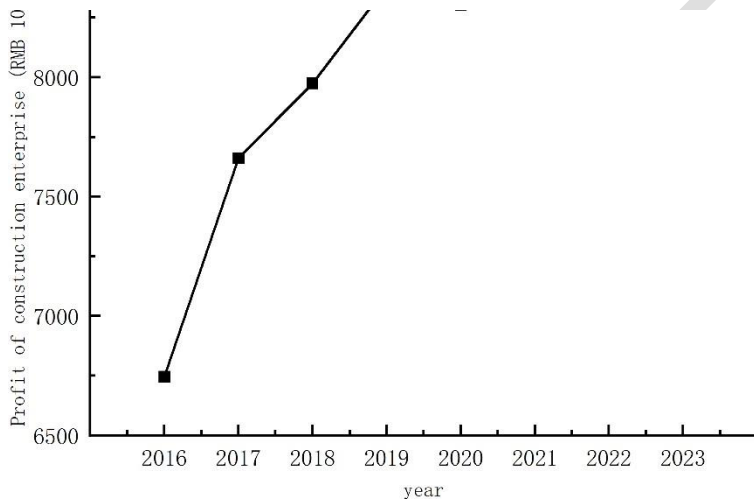


Fig. 1 Profits of qualified general contracting and professional contracting construction enterprises in 2016-2023

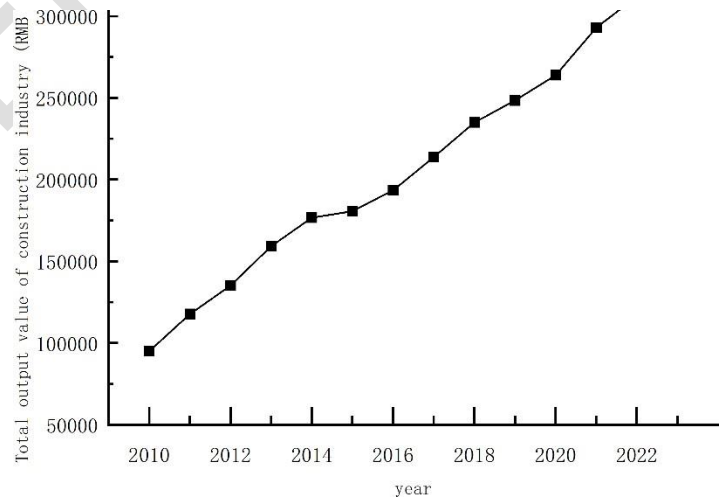


Fig. 2 Total output value of construction industry, 2010-2023

According to the data released by the National Bureau of Statistics, as shown in Table 1 and 1-2, the total output value of China's construction industry in 2023 increased by 5.8%, the investment in real estate development decreased by 9.6%, the newly started area of housing fell by 20.4%, and the funds in place of real estate development enterprises fell by 13.6% this year. In the first half of 2024, China's real estate development investment fell by 10.1%, and the sales area of new commercial housing in the country was 479.16 million square meters, down 19.0% year-on-year; The sales volume of new commercial housing was 4,713.3 billion yuan, down by 25%. The data of the past two years show that the development investment, construction area and sales area of real estate enterprises have declined significantly. The development of the construction industry has fallen into a downturn under the severe macro situation such as turbulence in the international environment, repeated delays of the epidemic, shrinking demand, supply shocks, and weakening expectations. In the face of external force majeure that cannot be broken through, how to save costs and improve efficiency for construction projects has become the primary problem for the development of construction enterprises. For a long time, the traditional extensive management mode has caused a large amount of waste of resources in the construction process of the project, and the schedule lag caused by the scheduling is not timely. The key to cost saving is to change the management style to the fine direction. At the same time, the construction industry also has the problem of low informatization and intelligence. In the concept of intelligent construction, the purpose of fine management of construction costs will also be doubled with half the effort. The research on the fine management of construction projects under the concept of smart construction is aimed at promoting the high-quality growth of the economy and society and promoting the sustainable development of the industry.

Table 1 Economic indicators of real estate development in January-June 2023 and 2024

Exploitation of real estate	Absolute amount (2023)	Year-on-year growth (%)	Absolute amount (January-June 2024)	Year-on-year growth (%)
Real estate development investment (100 million yuan)	110913	-9.6	52529	-10.1
Building construction area (10,000 square meters)	838364	-7.2	696818	-12
New construction area (10,000 square meters)	95376	-20.4	38023	-23.7
Completed area (10,000 square meters)	99831	17.0	26519	-21.8
Sales area of commercial housing (10,000 square meters)	111735	-8.5	47916	-19
Sales of commercial housing (10,000 square meters)	116622	-6.5	47133	-25
Funds in place for real estate development enterprises (RMB 100 million)	127459	-13.6	73894	-22.6
Commercial housing area for sale (10,000 square meters)	67295	19.0	53538	15.2

3. A REVIEW OF THE RELEVANT THEORIES OF INTELLIGENT CONSTRUCTION AND FINE MANAGEMENT OF ENGINEERING PROJECT CONSTRUCTION

3.1 Overview of relevant theories of intelligent construction

In recent years, driven by the wave of global industry 4.0 reform, China's construction industry has implemented industrialization reform. Currently, artificial intelligence, Internet of Things, automation and other technologies continue to play a role in helping construction projects. In order to adapt to this trend, intelligent construction has emerged as the primary direction of innovation management [2]. Dr. Yang Baoming explained in "Smart Construction in the Low-carbon Era" that "smart construction" has two meanings: first, the harmonious development of the industry and the harmonious and sustainable development of nature. China's construction industry scale accounts for about 50% of the world, construction steel cement accounts for about 50% of the world, is the largest industry in resource energy consumption, energy consumption and pollution industry, the implementation of fine management to reduce consumption and emissions do not wait. The second is to equip the industry with advanced digital nervous systems. Both industries, enterprises and project management are supported by advanced information technology systems, with fair and transparent operating environment and efficient and fine project management [3].

The intelligent construction technology is mainly through the diversified application of CAD technology, BIM technology, VR technology, big data technology and database technology, the implementation of visual design and integrated management and assembly production in the construction project production and construction, and the improvement of the intelligent level of the construction stages of "project decision-making - design - procurement - construction - operation and maintenance". Practical experience shows that through the application of building wisdom construction technology, it can better promote the integrated development of building design and construction. Smart construction not only meets the requirements of lean construction, but also the inevitable requirements of sustainable social development. Scientific and technological progress has brought great economic benefits. Because smart construction will integrate a large amount of information, enterprises have plenty of choice in construction resources. In particular, after the use of smart construction technology, it can not only analyze the appearance and space design, but also calculate the cost of building materials and consumption, control the engineering cost more scientifically and accurately, and control the benefit from the cost. Smart construction unified management of the engineering design and construction process, the use of logic, synthesis and other technical means, scientific planning of engineering operations. Thus saving time cost and construction cost, improve the efficiency of construction. Smart construction has also gradually formed an industrial chain, integrating materials, equipment, and technology, so that various technical resources can directly reach the construction site, greatly saving transportation and storage costs, and realizing the extension and expansion of the overall benefit. Therefore, at present, intelligent construction has gradually become the primary task of enterprise construction.

3.2 A review of the related theories of fine management

Fine management is a kind of concept, but also a kind of culture. Originating in developed countries, Taylor published the Principles of Scientific Management in 1911, which is the world's first fine management work. With the advancement of The Times, fine management is the inevitable requirement of fine social division of labor, efficient production process and high standard of product quality. It is a management method based on conventional management, which maximizes resource saving, reduces management cost and improves

management efficiency. Fine management was initially applied in the manufacturing industry, through centralized monitoring of the whole production process from the production of materials to the storage of finished products, collection of all events occurring in the production process, and control of material consumption, equipment monitoring, product testing, etc., to create a fast response and flexible fine management platform for enterprises. For the definition of fine management, Chinese scholars have also given interpretation through research. Mr. Wang Zhongqiu explained that refined management is a management concept and technology. It is a management method that makes each unit in the organization run accurately, efficiently, cooperatively and continuously through the systematization and refinement of rules and the use of procedural, standardized, data-oriented and information-based management means. At the same time, it also pointed out that: Fine management is a kind of management method that gradually refines the management work from the macro level to the micro level on the basis of the extensive management in the past to improve the quality and efficiency, so as to enhance the competitiveness of enterprises.

The application of fine management to the construction process is to identify key problems and weak links in accordance with the "fine" idea, carry out in stages, complete a system in each stage, implement operation, improve a system, and modify the relevant system, only in this way can the final integration of the whole system. To realize the function, effect and role of fine management engineering in the development of enterprises. At the same time, we must also clearly realize that in the process of implementing the "fine management project", the most important thing is to have the consciousness of combining standardization and innovation. The realm of "refinement" is the best combination of standardization and innovation of management. This kind of refinement construction mainly relies on intelligent means to carry out fast and efficient calibration of design results on the construction site, which is reflected in the comprehensive and accurate guidance of project construction. It is reflected in the scientific management of various detection and analysis data; It is reflected in the accurate management of each work point, work surface and so on. In the past, problems that could not be solved by traditional manual methods could be solved by intelligent means.

4. THE WAY TO REALIZE THE FINE MANAGEMENT OF ENGINEERING PROJECT CONSTRUCTION UNDER THE CONCEPT OF INTELLIGENT CONSTRUCTION

4.1 Relevant national policy

According to the "14th Five-Year Construction Industry Development Plan" issued by the Ministry of Housing and Urban-Rural Development in 2022, the main task of the construction industry at this stage is to accelerate the coordinated development of intelligent construction and new building industrialization. 1. Improve the smart construction policy and industrial system. We will implement smart construction pilot demonstration initiatives, develop a number of pilot cities, build a number of demonstration projects, and summarize and promote replicable policy mechanisms. Strengthen the research and development of basic commonalities and key core technologies, and build an advanced and applicable intelligent construction standard system. We will publish typical cases of innovative services for new technologies and products in intelligent construction, compile white papers on intelligent construction, and promote digital design, intelligent production, and intelligent construction. Cultivate intelligent construction industrial bases, accelerate the construction of talent teams, and form an intelligent construction industrial system that integrates the whole industrial chain including scientific research, design, production and processing, construction and assembly, and operation. 2. Consolidate the foundation of standardization and digitalization.

Accelerate the integrated application of building information modeling (BIM) technology in the whole life cycle of the project, improve data interaction and safety standards, strengthen the digital collaboration in all aspects of design, production and construction, and promote the delivery and application of digital results in the whole process of project construction. 3. Promote digital collaborative design. The application of digital means to enrich the method of scheme creation, improve the level of architectural design scheme creation. Large design enterprises are encouraged to establish digital collaborative design platforms, promote the integrated design of buildings, structures, equipment pipelines, and decoration, and improve the collaborative design capabilities of various specialties. Improve the depth requirements of construction drawing design documents, improve the level of fine design, and provide the basis for subsequent fine production and construction. Research and develop parametric and generative design software to explore the application of artificial intelligence technology in design. Research and application of geotechnical investigation information mining and integration technology and methods to promote the digitization of investigation process. 5. Build an Internet platform for construction industry. Efforts will be made to tackle common technologies underlying the construction industry Internet platform, and key technical standards, development guidelines and white papers will be compiled. Carry out the construction industry Internet platform construction pilot, explore system solutions suitable for different application scenarios, cultivate a number of industry-level, enterprise-level, project-level construction industry Internet platforms, and build government supervision platforms. Encourage construction enterprises, Internet enterprises and research institutes to cooperate, and strengthen the integration and application of new generation information technologies such as the Internet of Things, big data, cloud computing, artificial intelligence and blockchain in the construction field.

4.2 With intelligent construction as the background, it is the main path to realize the fine management of engineering project construction

4.2.1 BIM Technology

Building Information Modeling (BIM) integrates, processes, and integrates process data from multiple stages of project design, construction, and management. BIM covers a lot of software, according to the use of functions, BIM related software can be divided into core modeling software, structural analysis software, cost analysis software, deepening design software, visualization software and so on. Using BIM for 3D modeling can check the hidden structural problems in the plane drawings, communicate with technicians of all parties through the platform in time, upload the summary information of problems in the drawings, and update the drawings in time. At the same time, in the process of deepening the design of each professional content, it can improve the structure layout, reduce the amount of materials, and facilitate the construction operation. Combined with the cost module, green analysis and other professional software, the building information model can be deeply analyzed, and with the help of the platform, the state of cooperation and information communication can be realized. BIM technology can be combined with other technologies to try to carry out "BIM+" applications, including cloud computing, augmented reality, Internet of Things technology, laser scanning technology, big data technology, code inspection and automatic generation technology.

4.2.2 BIM+VR application

The application of BIM+VR system can intuitively simulate the construction process, change the construction drawing from two-dimensional to three-dimensional, so that the builder can find the immersive feeling through VR glasses. BIM+VR system construction process diagram The application of BIM+VR can effectively simulate the whole process of

engineering construction, and can intuitively locate key lines, reasonably divide working segments and rationally dispatch resources. The application of BIM and virtual technology can monitor and visually compare the differences between engineering construction and expectations in real time, which is conducive to the strict control of construction progress of engineering projects. Because in the process of construction management of engineering projects, the transmission of information is very important, it is necessary to strengthen communication and coordination, so as to ensure that the overall construction benefits of smart construction can be realized. This technology can demonstrate the original complex process one by one, making it vivid and easy to understand, and the experience can have the feeling of being in the scene, which has substantial significance for increasing the enthusiasm of construction personnel, realizing fine management and improving construction technology.

4.2.3 Monitoring System

The video surveillance camera is used as the main basic image acquisition unit to monitor the front-end scene in real time. The video picture is transmitted to the field control center through network transmission, and the real-time video information is synchronized to the cloud platform. While the platform side obtains the scene image, Intelligent systems such as embedded video recognition and behavior analysis technology are also used to analyze the clear video and images of the front-end feedback, including the identification of the activity of construction machinery and equipment, and the identification of whether the construction personnel correctly wear the hard hat, etc., which can provide timely feedback on abnormal situations and reduce the oversight of manual supervision. In addition, the popularity of personal terminals such as smart phones, smart tablets and smart watches can realize the capture of mobile cameras and upload the scene situation in real time.

4.2.4 Sensor technology

Sensing technology has been applied in engineering for a long time and has a wide range of applications. The sensor technology mainly uses various sensor equipment to install in the observation object or observation environment for regular data feedback, and collects the data of the sensor installed in the field with the help of supporting detection equipment, and then uploads the data to the platform for processing and analysis. Or directly import the data collected by the sensor into the application software for analysis first, and transfer the result data to the platform database for storage; Or to establish a wireless sensing line, when the relevant parameters change abnormally, a variety of real-time data information will be collected into the platform system, using the functional modules on the platform to analyze the data.

4.2.5 Radio Frequency identification technology

Radio frequency identification (RFID) is a technology that can achieve wireless data transmission within an effective distance without direct contact, and is one of the components of Internet of Things technology. RFID technology is the most widely used in engineering RFID tags, which have the characteristics of light weight, small size, long battery life and easy management. The application process of RFID tags is to first use the programmer to write the use of object information into the RFID tag, and then paste the label or other ways to combine with the use of the object, when you need to understand the object information, use the reader to read the information, you can transfer the object information to the cloud platform to facilitate later verification of information. RFID tags are mainly used for material management in the engineering construction process. During the construction process, there will be a large number of materials flowing at the site. Using radio frequency

identification technology, objects can be identified and stored information can be obtained without manually viewing the tags. RFID tags can also be used for product information identification of concrete components pouring and production processes, which can record attribute data at various stages of production, which is conducive to the quality traceability of concrete components. It is recommended that radio frequency identification technology can operate in harsh environments, as long as it is within an effective distance, it can automatically identify the real-time location and other relevant information of the corresponding personnel, materials and machinery without manual intervention, collect the information in the RFID tag through the reader, and transmit it to the platform layer for processing through the wireless network. The application of BIM and RFID technology in the management of the whole life cycle of prefabricated construction can reduce the problems that may occur in the traditional construction management, and ensure that the project is completed on schedule and on price. ^[4]

4.2.6 Building robots

The application of construction robots and automation technology helps to improve the production efficiency of the construction industry and is also an effective way to improve the labor-intensive status quo of the construction industry. When a large number of construction robots are put into use on the construction site, it is necessary to use communication technology to connect all construction robots with the platform layer system, real-time transmission of fuselage status information, working conditions, positioning information and other information to form systematic management. When a construction robot fails, the information is fed back to the manager through the communication layer and the platform layer, and the fault can be cleared in time. At present, some domestic construction enterprises carry out independent research and development of intelligent construction robots, and the robots developed can complete simple repetitive tasks such as independent laying of floor tiles and automatic assembly of light steel keel ^[5].

4 EXISTING PROBLEMS

4.1 Talent construction needs to be expanded

To achieve fine construction management under the background of intelligent construction requires continuous innovation of science and technology. Scientific and technological innovation needs the participation of scientific and technological talents, and also depends on the support of strong scientific and technological strength. Every enterprise should take the construction of talents as a long-term strategic goal, put the cultivation of talents as the primary task on the agenda, cherish and care for talents, create conditions for the cultivation of talents, and encourage talents to contribute more in the process of enterprise development.

4.2 Standard construction needs to be strengthened

Industry standards are also improving with the improvement of fine management level. Innovation management scientists believe that when each unit carries out work with the same goal, it should coordinate and balance different problems and interests, including unified standards. If they do not cooperate with each other in fine management standards, it will be difficult to achieve the same goal. Perform tasks in strict accordance with prescribed standards; If there is no unified standard, the relevant managers of enterprises should accelerate the construction of unified standards, both construction personnel and enterprises

should make concerted efforts to promote the improvement of construction fine management level under the background of intelligent construction.

4.3 Strengthen platform construction

It is necessary to accelerate the construction of platforms based on advanced technologies such as integrated big data, automation and intelligent devices to meet the requirements of data collection, transmission, analysis and storage. In the Industry 4.0 era of continuous innovation of science and technology and continuous innovation of construction management software, enterprises should also have a long-term development vision and accelerate the pace of development. According to the actual situation of enterprises, we should adhere to unified management, promote the continuous improvement of the level of fine management platform, and strengthen the combined application of fine management platform and science and technology.

5 CONCLUSIONS

The development of the construction industry is depressed due to various factors. Therefore, the traditional extensive management method needs to be changed urgently. In the context of intelligent construction, we can apply big data, cloud computing, monitoring system, sensor system, radio frequency identification and other technologies to carry out fine management of the construction process, which can save a lot of resources, carry out reasonable scheduling of personnel and machinery, supervise personnel to monitor the operation in real time, and obtain the maximum economic benefits. However, it still needs to be further strengthened in terms of platform construction, talent construction and standard construction.

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